A National Program of Research for

FARM LABOR AND MECHANIZATION

Prepared by

A JOINT TASK FORCE OF THE
U. S. DEPARTMENT OF AGRICULTURE
AND THE STATE UNIVERSITIES
AND LAND GRANT COLLEGES

FOREWORD

The United States Department of Agriculture and State Agricultural Experiment Stations are continuing comprehensive planning of research. This report is a part of this joint research planning and was prepared under recommendation 2 (page 204, paragraph 3) of the National Program of Research for Agriculture.

The task force which developed the report was requested to express their collective judgment as individual scientists and research administrators in regard to the research questions that need to be answered, the evaluation of present research efforts, and changes in research programs to meet present and future needs. The task force was asked to use the National Program of Research for Agriculture as a basis for their recommendation. However, in recognition of changing research needs it was anticipated that the task force recommendations might deviate from the specific plans of the National Program. These deviations are identified in the report along with appropriate reasons for change.

The report represents a valuable contribution to research plans for agriculture. It will be utilized by the Department and the State Agricultural Experiment Stations in developing their research programs. It should not be regarded as a request for the appropriation of funds or as a proposed rate at which funds will be requested to implement the research program.

- - - -

This report has been prepared in limited numbers. Persons having a special interest in the development of public research and related programs may request copies from the Research Program Development and Evaluation Staff, Room 318-E Administration Bldg., USDA, Washington, D.C. 20250.

September 1968

PREFACE

This report presents the results of a study of farm labor and mechanization research in the United States. It considers the essential need for increased mechanization in farming to reduce labor inputs and improve efficiency in production. Labor is viewed as a physical rather than a sociological resource. The report provides an inventory of farm labor and mechanization research for 1965 and 1966, evaluates the present status and prospects for the development of mechanization and labor-saving technologies, and recommends the allocation of resources for related research in 1972 and 1977.

Membership of the Joint USDA-SAES Task Force to evaluate farm labor and mechanization research in the United States was as follows:

USDA appointments were by Dr. George L. Mehren, Assistant Secretary of Agriculture.

Linley E. Juers, ERS, Co-chairman
Richard G. Garner, CSRS
*Glen E. Vanden Berg, ARS
Raymon E. Webb, ARS
Velmar W. Davis, ERS - Staff capacity

*Walter M. Carleton, ARS and M. Conner Ahrens, ARS, substituted for Glen E. Vanden Berg during his absence from Task Force meetings.

SAES appointments were by Dr. Ray Lovvorn, Chairman of Experiment Station Committee on Organization and Policy.

D. W. Barton, Director, New York State Agricultural Experiment Station, Geneva - Co-chairman
*B. A. Stout, Michigan State University, East Lansing
Kenneth Tefertiller, University of Florida, Gainesville
Eric Thor, University of California, Berkeley

*G. E. Rossmiller, Michigan State University, substituted for B. A. Stout during his absence from Task Force meetings.

The Task Force set these objectives for the study:

1. Define the scope and goals of farm labor and mechanization research.

2. Evaluate the character and effectiveness of the current research on farm labor and mechanization.

3. Recommend research needed during the next decade (1972 and 1977) including priorities and time elements when applicable.

TABLE OF CONTENTS

SUMMARY

This report was prepared by a Joint USDA-SAES Task Force with the primary responsibility of reviewing and recommending future allocation of resources for farm labor and mechanization research. Labor was viewed as a physical rather than a sociological resource. The major effort of the Task Force was devoted to problem areas concerned with mechanization and use of systems analysis in the production of fruit and vegetables. In addition, research pertaining to mechanization and use of systems analysis in the production of field crops and livestock was reviewed.

As background information, three general topics are examined briefly: (1) structural changes in farming, (2) current and prospective productivity of labor and (3) potential for capital-labor substitution. The goals of farm labor and mechanization research are outlined and the expenditures and scientist man-years allocated to this research are examined. Then, five problem areas related to farm labor and mechanization are reviewed, with recommended allocation of scientist man-years for 1972 and 1977.

Farm Labor and Mechanization in Perspective

Farms have increased in size and specialization of enterprises, use of machines and other technology, and dependence on the nonfarm economy for inputs. Farms have grown larger partly because a worker with modern machines can handle more acreage and output than formerly, and partly because more assets are required per farm to adopt modern technologies such as new machines. Decline in farm employment is largely associated with the decline in number of farms and the increase in mechanization that have been the general trend since the 1930's.

The annual average number of farmworkers dropped from 9.9 million in 1950 to 4.9 million in 1967, a decline of 51 percent. Family workers constituted about three-fourths of all farmworkers in 1967. The balance was hired workers.

Although the annual average number of hired workers in 1967 was about 1.3 million, over 2.8 million people did some farmwork for wages in the year. A large proportion of these workers did only a few days of work, mainly at time of most critical need in the summer and fall. Over half lived or worked in the South, and the majority worked on large farms. In contrast to the declining number of farmworkers, employees in farm-related industries increased slightly from 11.5 million in 1950 to 12.5 million in 1964.

Insight into the productivity of farm labor can be obtained by comparing the man-hours per $100 of production for various commodities. The variation is greater among the different crops and types of livestock than it is between the two major commodity groups. So far as livestock is

concerned, the man-hours per $100 of production in recent years range from a low of 4 for broilers to a high of 42 for chickens raised. Even wider extremes occur in crop production with the range from a low of 6 for dry field peas and rice to a high of 67 for sugar cane and tung nuts.

In 1967, the index of farm output per man-hour stood at 167 percent of the 1957-59 average. It is projected to reach 312 percent of the same base in 1980. About a third of the recent rise in farm output per man-hour is attributable to factors that have increased production, such as greater use of higher yielding hybrids and varieties of plants and animals; increased use of fertilizer; more effective weed, insect, and disease control; and more productive livestock rations, including feed additives. The other two-thirds has resulted from adoption of labor-saving techniques. The projected increase in farm output and the greater increase in farm output per unit of labor indicate that about a third less labor will be used in 1980 than in 1967.

In examining the potential for capital-labor substitution, it is helpful to divide farm production into two broad classes. First, in grain and cotton production, future capital-labor substitution possibilities consist of substituting larger machines for smaller ones or substituting chemical or biological forms of inputs for mechanical forms of capital.

The second type of production includes fruits, vegetables, nuts and other speciality crops, and is characterized by a low level of mechanization and high labor requirements per unit of production. At present levels of technology, future capital-labor substitution will consist of substituting machine methods for hand methods rather than larger, more efficient machines being substituted for smaller machines.

Most of the livestock production comes under the same category as grain production. Technology in the form of materials-handling equipment and housing is available or is becoming available which permits substitution of capital for labor. The extent to which substitution will occur depends upon fixety of resources in production, relative costs of capital and labor, and size of production units.

Goals

Farm labor and mechanization research is directed towards meeting the broad agricultural research goal of assuring production of food and fiber to meet the needs and opportunities of America for domestic consumption and export. More specifically, this research seeks to: (1) reduce farm labor requirements and improve efficiency in the production of crops and livestock through mechanization, and (2) through systems analysis, combine that set of production and marketing practices with land, labor, capital, and management inputs that will optimize income from the production of crops and livestock.

Research to Meet Future Needs

The Task Force's major effort was devoted to problem areas concerned with mechanization and use of systems analysis in the production of fruit and vegetables. Research pertaining to mechanization and use of systems analysis in the production of field crops and livestock was also reviewed. A summary of the recommended SMY's total USDA and SAES for 1972 and 1977 by problem areas is as follows:

Problem areas	Scientist Man-Years		
	Inventory : FY 1966	Recommended for 1972	1977
305 - Mechanization of fruit and vegetable production.....	65	120	169
306 - Systems Analysis in production of fruit and vegetable production.....	7	15	20
308 - Mechanization of production of field crops.....	100	110	120
309 - Systems analysis in production of field crops.....	43	57	72
313 - Improved livestock and poultry management systems.....	134	184	233

Fruit and Vegetables

Cultural practices in citrus production are highly mechanized. Yet, the picking operation is done by hand. Some mechanical picking aids, platform and picker positioners have been developed. The fruit handling operation between grove and plant is partly mechanized.

All of the mechanical harvesting techniques developed so far cause more injury to the fruit than hand harvesting. Thus, grapefruit and oranges (excluding valencias) intended for processing will likely be first to be harvested mechanically.

Citrus trees grow so slowly that breeding crop varieties better adapted to mechanical harvesting than the present ones is a long-range project. More likely approaches are those of developing chemicals to cause the fruit to separate more easily from the tree and horticultural techniques such as planting in hedgerows to facilitate mechanical harvesting. Certain citrus fruits have characteristics that seem to be unfavorable to mechanical harvesting. Valencia orange trees contain blooms, immature fruit, and mature fruit at the same time. Tangerines and murcotts have to be clipped

rather than pulled or shaken from the tree. Other specialty citrus is sold for fresh use and cannot withstand the additional bruising of mechanical harvesting.

In summing up the state of mechanization in deciduous and small fruits and tree nuts, we find far greater advances in mechanization of that portion of the crop which goes to processing, with little or no progress in the harvest of that part of the crop destined for the fresh market. Roughly about two-thirds of the $1.3 billion deciduous and small fruit crop goes to processing.

Mechanical harvesters have been effective on tree nuts, tart cherries and blueberries. They have achieved limited success on the processing portion of the apple, peach, plum, and prune crops. Additional labor reductions on deciduous and small fruits and tree nuts are anticipated through improved pruning, thinning, harvesting, and handling techniques.

In white potato production, labor requirements have been reduced through mechanization of tillage, seeding, pest control, and harvesting. The shift to bulk handling in both pre-seeding and post-harvesting is essential for further labor and cost reduction.

Approximately 390 million man-hours were employed in 1966 to produce and harvest the nation's vegetable crops. The number of hours required has decreased at an annual rate of approximately 2 percent during the past decade. This is largely a result of increases in the proportion of vegetables marketed in processed form rather than as fresh produce.

Mechanization has come to the vegetable industry in many ways. The need for hand labor for thinning and weeding most vegetables has been reduced by the adoption of mechanical seeders and precision planters, mechanical thinners, and selective herbicides.

In evaluating the research on the mechanization of fruit and vegetable production, three commodity categories were considered high in priority for increased SMY's during the next decade. Of special urgency, in the near future, is the need for a rapid increase in the engineering effort on the mechanization of the citrus harvest. Thus, the Task Force recommends an increase in SMY's from 14 in 1966 to 40 by 1972 and 58 by 1977. While the individual needs of deciduous and small fruit and nut crops are not as immediate as in citrus production, the diversity of the crops necessitates a substantial, almost threefold, increase in the engineering effort from 22 SMY's in 1966 to 61 SMY's by 1977.

Remarkable progress has occurred in the mechanization of production and harvest of a few vegetables such as tomatoes for processing, sweet corn, carrots, peas, and snap and lima beans. Progress has been slow for others because of uneven ripening and the inability of the vegetable to withstand the bruising received from mechanized equipment. Mechanization of one or more crops in an area often reduces opportunity for employment available in an area. Labor supply declines. This puts a special urgency on those crops not now mechanized. Thus, these factors plus the diversity of vegetable crops justify an increase from the allocation of 21 SMY's in 1966 to 43 SMY's in 1977.

The recommendation of the Long Range Research Planning Committee to increase SMY's from 7 in 1966 to 20 in 1977 for systems analysis in the production of fruit and vegetables is accepted. Emphasis in the future allocation should be given to vegetables, new crops, and deciduous and small fruits and tree nuts.

Field Crops

In 1940, 8.8 billion man-hours were used to produce field crops compared with 2.7 billion in 1967. Technology is now available which permits most jobs in the production of field crops to be done by machine. Gains in productivity per man-hour have been rapid for feed grains and cotton but slow for tobacco and hay. Future advances are likely to occur in the substitution of larger machines for smaller ones and the redesign of current machines or systems to improve efficiency.

An examination of the 100 SMY's allotted to RPA 308 in 1966 indicates that they are spread among 15 commodity groupings and in many cases are so few as to be almost ineffective. It is also recognized that private industry supports a substantial research and development program to improve the mechanization of field crops. While the National Program of Research for Agriculture recommends only a modest increase of 20 SMY's for RPA 308, this Task Force further recommends a change in the distribution of SMY's so that larger efforts can be made in key areas.

Tobacco, hay, and cotton appear to have the most potential for reducing labor requirements through mechanization. Tobacco is the largest user of labor, 476 million man-hours, and requires 38 man-hours per $100 of production. Hay and cotton are also major users of labor with relatively high labor requirements, 12 to 26 man-hours per $100 of production. The development of a technology that would reduce labor by only 1 percent would have significant benefits to agriculture. In sharp contrast, corn is also a major user of labor with 331 million man-hours in 1966, but only 7 man-hours per $100 of production. Improvement in mechanization of corn will likely increase production and improve quality of product rather than substantially reduce labor.

In the use of systems analysis in the production of field crops, the Task Force endorses the recommendation of the National Program of Research for Agriculture to increase the SMY's from 43 in 1966 to 72 in 1977. No attempt was made to allocate SMY's by commodities. Rather, the emphasis should be on an interdisciplinary approach to the development of methodology, collection of data and analysis.

Livestock

The objective of research concerned with improved livestock and poultry management systems is increased efficiency and optimization of all production inputs. However, this Task Force concentrated only on labor inputs and labor and mechanization in a systems analysis context.

Of concern to the livestock industry are the different economies associated with the production of livestock. For example, broiler growing is a highly developed production-management system with a minimum labor input. Broilers require only 4 man-hours for $100 of production. This is in contrast to other enterprises that have experienced a limited degree of improvement in production management as evidenced by the following man-hours for $100 of production: chickens raised--42; milk--21; sheep and wool--17; hens and eggs--16; beef cattle--10; and hogs--7.

Production of broilers and turkeys, once minor enterprises, have attained commercial status on many farms. Mechanical and automated methods of feeding and caring for poultry are now common practices. By 1980, production of poultry products per man-hour is projected to reach at least 1.3 times the 1967 level. In milk production, the widespread use of labor-saving equipment, larger herds, and handling of milk in bulk and with pipeline installations have drastically reduced labor requirements.

Improvement in production of meat animals per man-hour of labor has lagged behind that in other livestock production. Many producers of cattle, hogs, and sheep use tractor-mounted forks and scoops for feeding and for cleaning sheds and lots, but much hand work is still done. Modern feeding systems, such as self-fed and automatically-timed feed grinders and mixers and pneumatic feed distributors, usually involve considerable investment in new or remodeled buildings, power units, and equipment. With labor available, it has not been economical to invest in labor-saving systems.

Basic to the reduction of labor in the mechanization of livestock production is efficient materials handling. Materials handling problems are concerned with feed, animal wastes, and animal products. Much farmstead equipment has been adapted from industrial uses and does not have the reliability or the desired efficiency when operating in a farmstead environment. Since the farm market is small compared to large industrial markets and short-line manufacturing companies usually do not have the capital to invest in research, needed research to improve farmstead equipment often is not done. Thus, some USDA-SAES resources need to be allocated to the

development of farmstead equipment and materials handling systems.

The Task Force concurs in the recommendation to increase the SMY's from 134 SMY's in 1966 to 233 SMY's in 1977. Recognizing that substantial efforts are being made to obtain funds for a large-scale attack on waste disposal, the Task Force urges that the program on waste disposal be implemented since improved technologies in manure handling and disposal will likely reduce labor requirements in livestock production. In addition, emphasis in the allocation of new SMY's and even reallocation of current SMY's should be given research related to labor-saving equipment for general cleaning, manure removal, and sanitation.

I. FARM LABOR AND MECHANIZATION IN PERSPECTIVE

Agriculture has had both a labor shortage and a labor surplus. From the farmer's viewpoint, the supply of labor has seldom been adequate in either numbers or skills at the wage rates they have been willing to pay. But between seasons we have had underemployed labor on many farms. From the worker's viewpoint, farm labor is unattractive because of the seasonality of most farm jobs, low wages, the lack of standard social protection and benefits, and the very low social status that is accorded farmwork.

In evaluating current and future research related to farm labor and mechanization, three general topics were examined:

1. Structural changes that have occurred in agriculture.
2. Current and prospective productivity of labor.
3. The potential for capital-labor substitution.

A. Structural Changes in Agriculture:

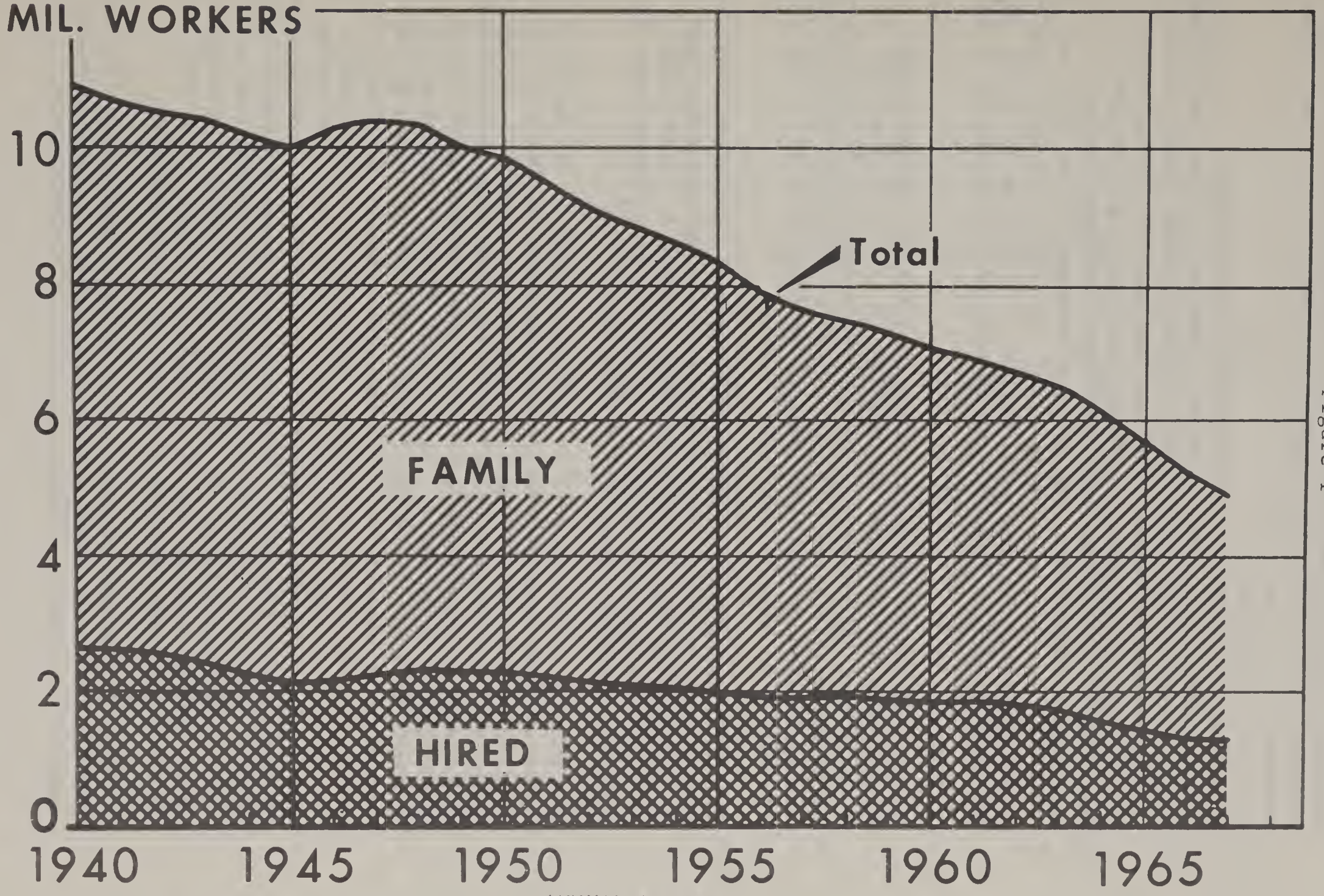
The technological revolution in farming has affected the structure of farming, and the changing structure has in turn affected the adoption of technology. Overall, farms have increased in size and specialization of enterprises, use of machines and other technology, and dependence on the nonfarm economy for inputs. Farms have grown larger partly because a worker with modern machines can handle more acreage and output than formerly, and partly because more assets are required per farm to adopt modern technologies such as new machines.

Decline in farm employment (fig. 1) is largely associated with the decline in number of farms that has been the general trend since the 1930's. In 1967, there were about 3.2 million farms in the United States, a reduction of more than 25 percent since 1958. On the other hand, farm workers have declined about 35 percent since 1958. Average farm acreage rose from 280 to about 359 acres during the last 10 years; and production assets per farm rose from an average of $35,200 in 1958 to $73,100 in 1967. 1/ During the same period, production assets per farmworker increased from $18,500 to $41,300. Farms of this size and value are equipped with complex

---

1/ A large part of the increase came from higher land values, but there was also an enlargement of the value of inventory in machines and other equipment. The decline in farms with few production assets and small acreage has greatly influenced the increasing size and value of the average farm plant.

FARM EMPLOYMENT, 1940-67



ANNUAL AVERAGES.

U. S. DEPARTMENT OF AGRICULTURE

NEG. SRS 144-68 (4) STATISTICAL REPORTING SERVICE

Figure 1

machinery and equipment that require a high level of technical and managerial skills by farm operators and their family and hired workers.

Historically, farming in the United States has been an industry of diversified enterprises. However, a definite trend toward product specialization has accelerated in recent years. Most farmers have eliminated small home-use enterprises, such as the family cow or the small flock of chickens, and many have found it profitable to specialize in the commercial production of fewer products. Of 25 major farm enterprises, the average farm had 5.3 in 1939, 4.7 in 1949, 4.1 in 1959, and 3.4 in 1964. Increased use of capital and farm specialization are major factors in reducing the total amount of labor needed in farming, and in changing the patterns of seasonal requirements for farm labor.

As part of the changing structure, the annual average number of farmworkers dropped from 9.9 million in 1950 to 4.9 million in 1967, a decline of 51 percent. Family workers declined 52 percent, and hired workers declined 46 percent (table 1 and fig. 1). Nationally, family workers constituted about three-fourths of all farmworkers in 1967. The balance was hired workers.

Type of farming largely determines regional variations in family versus hired workers. The intensive fruit and vegetable production in the Pacific Region requires large numbers of hired workers, particularly seasonal workers. It is the only region where hired workers outnumber those of the farm family.

The decline in family workers is closely tied to the adoption of advanced technology and the related decrease in number of farms, particularly those too small to justify the ownership of modern farm machines. The outward "push" resulting from farm mechanization plus the "pull" to higher paying nonfarm jobs are operative in the reduction of farmworkers. Many of the former farm operators, however, were qualified for little other than farmwork so have stayed on as wage hands. This has moderated the decrease in hired workers in the southern regions, particularly the Southeast. In the North, on the other hand, the type of farms, tenure arrangements, and increases in mechanization and related factors have reduced the demand for hired workers. The numbers of farms and family workers have been reduced significantly through consolidation of small units into larger operations. At the same time, family workers have been able, through greater use of mechanized methods, to do more of the farmwork, thereby reducing the need for hired workers.

Although the annual average number of hired workers in 1967 was about 1.3 million, about 2.8 million people did some farmwork for wages in the year. A large proportion of these workers did only a

Table 1.--Farm employment: Type of worker and region in 1967, and percentage change, 1950-67

Regions	1967			Percentage change 1950-67		
	Total	Family 1/	Hired	Total	Family 1/	Hired
	1,000	1,000	1,000	Percent	Percent	Percent
Northeast	387	283	104	-59	-56	-65
Lake States	550	483	67	-44	-42	-54
Corn Belt	900	774	126	-47	-46	-52
Northern Plains	372	318	54	-45	-44	-49
Appalachian States	810	619	191	-52	-55	-39
Southeast	423	268	155	-57	-65	-32
Delta States	371	254	117	-64	-67	-55
Southern Plains	427	310	117	-49	-48	-51
Mountain	259	156	103	-38	-42	-32
Pacific	404	185	219	-40	-46	-34
United States	4,903	3,650	1,253	-51	-52	-46

1/ Family workers include operators and unpaid family workers.

few days of work, mainly at time of most critical need in the summer and fall. Over half lived or worked in the South, and the majority worked on large farms.

From the farmer's viewpoint the uncertainty of the labor supply, lack of skill and rising labor costs will pressure him to find means for eliminating the need for part-time labor. Part-time labor can be eliminated by (1) reducing peak labor demands with a suitable mix of production enterprises under one management, (2) replacing labor with machines and automatic devices or (3) stop producing commodities requiring large amounts of part-time labor. From the laborer's viewpoint, the general undesirability of farm labor, particularly the seasonal aspect, suggests that they will continue to become less and less available unless other employment opportunities suddenly disappear. However, one cannot conclude that part-time labor supply or demand will disappear completely.

B. Productivity of Labor:

Insight into the productivity of farm labor can be obtained by comparing the man-hours per $100 of production for various commodities (table 2). The variation is much greater among the different crops and the different types of livestock than it is between the two major commodity groups. The man-hours per $100 of production range from a low of 4 for broilers to 21 for milk cows, and a high of 42 for chickens raised. Even wider extremes occur in crop production with the range from a low of 6 for dry field peas and rice to a high of 67 for sugar cane sirup and tung nuts.

Large amounts of labor are required for fruits and nuts, tobacco and hay. These three groupings require approximately 38 percent of the labor used on crops and yet account for only 26 percent of the crop production value. On the other hand, corn for grain comprises 23 percent of the crop production value and yet requires only 9 percent of the total crop labor. Similar comparisons can be made for livestock products.

In 1967, the index of farm output per man-hour stood at 167 percent of the 1957-59 average. It is projected to reach 312 percent of the same base in 1980 (table 3). About a third of the recent rise in farm output per man-hour is attributable to factors that have increased production, such as greater use of higher yielding hybrids and varieties of plants and animals; increased use of fertilizer; more effective weed, insect, and disease control; and more productive livestock rations, including feed additives. The other two-thirds has resulted from adoption of labor-saving techniques.

Table 2.--Production, man-hours of labor used and related factors, by products, United States, 1965-67

Product or enterprise	Production 1/		Man-hours of farmwork	Man-hours per $100 of production
	Value 1965-67 average	Percentage of total	1965-67 average	
	Mil. dol.	Percent	Mil. hours	Hours
Corn for grain	4,973	22.6	340	7
Oats	548	2.5	71	13
Barley	393	1.8	32	8
Sorghum grain	723	3.3	59	8
Hay	2,916	13.2	364	12
Sorghum forage	68	.3	17	25
Wheat	2,023	9.2	153	8
Rye	30	.1	9	30
Rice	413	1.9	23	6
Truck crops - processing 2/	455	2.1	106	23
fresh market 2/	1,097	5.0	191	17
Potatoes	643	2.9	66	10
Sweet potatoes	71	.3	16	23
Dry edible beans	141	.7	16	11
Dry field peas	17	.1	1	6
Fruits and nuts	1,568	7.1	544	35
Sugar beets	255	1.2	41	16
Sugar cane for sugar and seed	116	.5	38	33
Sugar cane sirup	3	3/	2	67
Maple sirup	6	3/	2	33
Cotton lint	1,380	6.3	355	26
Tobacco	1,261	5.7	478	38
Soybeans	2,377	10.8	176	7
Peanuts	277	1.3	29	10
Flaxseed	75	.3	5	7
Tung nuts	3	3/	2	67
All crops 4/	22,008	100.0	3,655	17
Beef cattle	7,548	35.3	790	10
Hogs	3,992	18.7	291	7
Sheep and wool	367	1.7	64	17
Milk cows	5,683	26.6	1,170	21
Hens and eggs 5/	1,936	9.1	313	16
Chickens raised 5/	108	.5	45	42
Broilers 5/	1,269	6.0	52	4
Turkeys	455	2.1	31	7
All livestock 6/	21,358	100.0	2,856	13
Farm output 7/ 8/	43,366		7,609	18

1/ Gross production of each production shown.

2/ Production of minor crops in minor producing States excluded. Included in man-hours.

3/ Less than 0.05 percent.

4/ Includes silage, forage, and miscellaneous crops not shown separately.

5/ Excludes production of miscellaneous livestock not shown separately.

6/ Includes labor on miscellaneous livestock not shown separately.

7/ Production value, sum of crops and livestock.

8/ Includes labor on horses and mules and overhead.

Table 3.--Farm production per man-hour: Index numbers, selected years and projections for 1980

1957-59=100

Enterprise or product	Averages		1967 1/	Projected 1980	Percentage increase 1967-80
	1949-51	1959-61			
					Percent
Farm output 2/	60	114	167	312	87
Livestock and livestock products	69	114	175	355	103
Meat animals	84	107	146	279	91
Milk cows	68	115	179	411	130
Poultry	49	125	214	461	115
Crops	60	113	159	272	71
Feed grains	48	127	218	507	133
Hay and forage	72	113	134	200	49
Food grains	49	118	131	221	69
Vegetables	68	111	129	199	54
Fruits and nuts	88	102	120	185	54
Sugar crops	53	111	132	210	59
Cotton	56	116	188	448	138
Tobacco	82	107	127	200	57
Oil crops	58	110	131	241	84

1/ Preliminary.

2/ Man-hours in ratio include labor used on crops, livestock (including horses and mules), and overhead.

The projected increase in farm output and the much greater increase in farm output per unit of labor indicate that about a third less labor will be used in 1980 than in 1967 (table 4). 2/ However, the reduction in use of labor attributable to adoption of machines will not be uniform among the farm enterprises or areas of the country.

Projections of continued improvement in labor productivity for livestock, coupled with projected increases in production, show that 1.6 billion man-hours of labor will be needed for livestock in 1980, compared with 2.9 billion in 1967. In other words, livestock production will require 43 percent less labor in 1980. The rate of mechanization and adoption of new technology in the livestock industry is likely to continue unevenly.

Future labor requirements for crops cannot be predicted with as much accuracy as for livestock. Development of new hybrids and varieties of crops is more advanced and production is dependent on more factors than are involved in livestock. Even so, projections show that crop production will require about 20 percent less labor in 1980 than in 1967.

C. Capital-Labor Substitution:

In examining the potential for capital-labor substitution, it is helpful to divide farm production into two broad classes. Grain production and more recently cotton production represent a type of farm production with rather distinct labor requirement characteristics. Fruits, vegetables, and specialty crops represent a separate class of products with different labor requirements. Livestock more nearly comes under the same category as grain production.

First, let us consider the products represented by grain production. For this class of products, technology is now available which permits most, if not all, functions to be done by machine. Future capital-labor substitution possibilities consist of substituting larger machines for smaller ones or for substituting chemical or biological forms of input for mechanical forms of capital. Questions arise about the rate of discard of smaller machines and the rate at which it is economically feasible to adopt the newer labor-saving methods. This adjustment process involves recombination of farms into larger production units, with release of labor as one consequence. With the exception of cotton farms,

---

2/ Projections of production are divided by projections of production per unit of labor to obtain projections of labor input. A major advantage of projecting production per unit of labor is that it reflects the net effect of all factors affecting either farm production or labor input.

Table 4.--Labor used for farmwork: Man-hours, selected years and projections for 1980

Enterprise or product	Averages		1967 1/	Projected 1980	Percentage change 1967-80
	1949-51	1959-61			
	Million hours	Million hours	Million hours	Million hours	Percent
All farmwork 2/	15,520	9,866	7,434	5,217	-30
Livestock and livestock products	5,501	3,889	2,858	1,623	-43
Meat animals	1,452	1,349	1,109	687	-38
Milk cows	2,727	1,754	1,124	511	-54
Poultry	1,134	605	461	261	-43
Crops	7,317	4,588	3,530	2,833	-20
Feed grains	1,484	747	515	315	-39
Hay and forage	693	509	489	329	-33
Food grains	362	184	207	136	-34
Vegetables	628	432	398	308	-23
Fruits and nuts	626	571	466	542	+16
Sugar crops	120	77	81	81	0
Cotton	1,657	838	276	225	-18
Tobacco	776	551	480	410	-15
Oil crops	196	168	225	194	-14

1/ Preliminary.

2/ Includes labor used on crops, livestock (including horses and mules), and overhead.

production units have typically been organized around the labor available from the farm family with hired labor of only minor importance.

Continuing with this generalization, it has been the food grains, feed grains and cotton which have been in over-supply and thus "too much" labor has been devoted to production of those commodities. Farm operators and other unpaid family workers have been willing to work for less than the prevailing wages of hired workers. Tobacco production, also in over-supply, is a labor-intensive crop and presumably at present does not have the same capital-labor substitution possibilities exhibited by grain and cotton production.

The second type of production includes fruits, vegetables, nuts, and other specialty crops. A principal difference in labor requirements between this kind of production and grain production consists of the level of mechanization available and the amount of labor required per unit of production. Planting and cultivating are largely mechanized, but the extent of additional mechanization varies among crops and is much further developed in some lines of production than others. Harvesting methods vary from use of a high proportion of hand labor to use of highly sophisticated machines. At present levels of technology, capital-labor substitution consists of substituting machine methods for hand methods rather than larger, more efficient machines being substituted for smaller machines. For some jobs, mechanization possibilities are limited because machines have not yet been invented or their performance is unsatisfactory because of plant characteristics which make them unsuitable for mechanization. Further mechanization depends upon development of suitable machines and development of varieties which are adapted to machine operations.

Typically, production of fruits, vegetables and specialty crops has been organized into economic units which require more labor during peak seasons than is available from the farm operator family. Thus, seasonal hired labor is required during peak seasons. Over-production of fruits, vegetables and specialty crops has been less a problem than for grains and cotton. Labor has been more a "shortage" problem than a "surplus" problem.

When this classification scheme is extended to livestock production, it appears that most, if not all, livestock production comes under the same heading as grain production. Technology in the form of materials-handling equipment and housing is available or is becoming available which permits substitution of capital for labor. The extent to which substitution has occurred has depended upon fixety of resources in production, relative costs of capital and labor, and size of production units.

II. SCOPE AND PROCEDURES USED IN STUDY

The research problems related to farm labor and the impact of mechanization on labor and agricultural production depend on whether they are viewed from the standpoint of the farmer or the hired worker. Labor is viewed by the Farm Labor and Mechanization Task Force as a physical input of which there is an increasing demand for more highly skilled and trained workers. The importance of sociological problems related to farm labor are recognized by this Task Force, but the evaluation of such problems was assumed to be the responsibility of Task Force 31 - Rural Devleopment.

A. Scope:

The scope or the parameters of responsibility of the Task Force were defined by the Joint USDA-SAES Task Force that conducted the Long Range Study (LRS). The primary responsibility of Task Force 33, Farm Labor and Mechanization, was to review and make recommendations concerning LRS problem areas:

305 - Mechanization of fruit and vegetable production; and
306 - Systems analysis in production of fruits and vegetables.

Although Task Force 33 did not have "primary responsibility," it was expected to make recommendations dealing with appropriate portions of the following problem areas:

308 - Mechanization of production of field crops;
309 - Systems analysis in production of field crops;
313 - Improved livestock and poultry production management systems; and
316 - Farm adjustment and management.

After a review of the assignment, the Task Force modified the parameters of responsibility by excluding 316 - Farm Adjustment and Management.

B. Criteria for Evaluating Research:

Criteria developed by the Joint USDA-SAES staff for judging the relative importance of research areas were adopted. 3/

3/ See pages 29 and 30 of the report, "A National Program of Research for Agriculture," sponsored by the Association of State Universities and Land Grant Colleges and U. S. Department of Agriculture, October 1966.

The criteria and weights were as follows:

Weight	Criteria
9	A - Extent to which the research meets State Experiment Station, Department and National goals (and Task Force goals).
8	B - Scope and size considering area, people, and units (commodity) affected.
7	C - Benefits of research in relation to costs.
10	D - Urgency of research
9	E - Contribution to knowledge.
5	F - Feasibility of implementation and likelihood of successful completion in a reasonable period of time.
6	G - Likelihood that research results will not be available elsewhere.
6	H - Likelihood of extensive and immediate adoption of results.

The use of these criteria involved giving a score ranging from 1 to 5 for each problem for the degree to which it met each of the criteria. The score was multiplied by the weight assigned to the criterion in question and the values of all criteria were summed to give a total score.

As an additional aid in scoring each criterion, the guidelines developed by the Soybean Task Force were used (See Appendix A, page 55).

III. GOALS OF LABOR AND MECHANIZATION RESEARCH

Goals of farm labor and mechanization research should be directed towards fulfilling the role in meeting the broader agricultural research goal III., "Produce an adequate supply of farm and forest products at decreasing real production cost." This goal is concerned with assuring production of the food and fiber to meet the needs and opportunities of America for domestic consumption and export.

A. Mechanization of Crop Production:

To reduce farm labor requirements and improve efficiency in the production of crops through mechanization. More specifically the objectives are:

1. Develop machines and improved machine components to plant, cultivate, harvest, and handle specific crops.

2. Develop precision devices and automated systems of machine operation.

3. Develop tillage units to minimize power requirements, number of operations, and provide optimum seedbed conditions.

4. Determine and develop principles relative to mechanical and rheological properties of crop products to facilitate development of equipment and procedure for handling.

5. Modify varieties and cultural practices to provide plants adapted to mechanized operations.

B. Mechanization of Livestock Production:

To reduce farm labor requirements and improve efficiency in the production of livestock through mechanization. More specifically the objectives are:

1. Develop improved automatic equipment for feeding, watering, bedding, and handling poultry and livestock.

2. Develop labor-saving equipment for general cleaning, manure removal, and sanitation.

3. Develop improved milking machines capable of drawing milk without deleterious effects of the machine on dairy cows, and that will require a minimum of labor.

C. Systems Analysis in the Production of Crops and Livestock:

Combine that set of production and marketing practices with land, labor, capital, and management inputs that will optimize income from the production of crops and livestock. More specifically, with emphasis on the reduction of labor through mechanization, the objectives are:

1. Develop systems of production that will increase efficiency and income through the reduction of labor, equipment and facilities.

2. Provide data that will assist farmers in the selection of enterprises and the kind, amount, and combination of inputs (such as labor and machinery) that will give maximum efficiency in farm enterprises.

3. Develop improved methods of storing, processing, and distributing feed to livestock.

4. Develop more efficient methods of animal waste collection and removal from barns and feedlots.

IV. EXPENDITURES AND SMY'S ALLOCATED TO LABOR AND MECHANIZATION RESEARCH PROBLEM AREAS FOR FISCAL YEARS 1966 AND 1967

The research problem areas considered within the parameters of responsibility of the Farm Labor and Mechanization Task Force were as broad as total farm production. Some problems were specific in terms of mechanization (LRS problem areas 305 and 308) and systems analysis (LRS problem areas 306 and 309). The remaining problem area (LRS problem area 313) represented combinations of mechanization, systems analysis, and resource and financial management. However, focus of the Task Force was on labor and mechanization research problems.

The current allocation of expenditures varies widely by problem areas. For example, expenditures for problem area 313--Improved Livestock and Poultry Production Management Systems, were about $8 million in FY 1967 compared with about $2 million for problem area 305--Mechanization of Fruit and Vegetable Production. A further contrast is the relatively small input of resources allocated to systems analysis. In FY 1967, only 8 SMY's were allocated to problem area 306--Systems Analysis in the Production of Fruits and Vegetables, whereas 47 SMY's were devoted to problem area 309--Systems Analysis in the Production of Field Crops.

A summary of the allocation of expenditures and SMY's for the problem areas considered by the Task Force is as follows(See Appendix B, tables 1-5 for the allocation of expenditures and SMY's by types of crops and livestock, page 57):

	Expenditures by Fiscal Years ($1,000)		Scientist Man-Years by Fiscal Years	
	1966	1967	1966	1967
305 - Mechanization of Fruit and Vegetable Production (Appendix table 1).....	1,900	2.019	64.9	64.6
306 - Systems Analysis in the Production of Fruit and Vegetables (Appendix table 2).....	283	299	7.1	8.3
308 - Mechanization of Production of Field Crops (Appendix table 3).....	3,929	3,995	100.3	105.2
309 - Systems Analysis in Production of Field Crops (Appendix table 4).....	1,518	1,628	42.6	46.8
313 - Improved Livestock and Poultry Production Management Systems (Appendix table 5).....	7,382	7,779	137.0	142.8

V. RESEARCH TO MEET FUTURE NEEDS

A. Introduction

The major effort of the Task Force was devoted to the two principal problem areas: 305--Mechanization of Fruit and Vegetable Production and 306--Systems Analysis in the Production of Fruits and Vegetables. As a guide in recommending future allocation of SMY's, each member of the Task Force rated the major commodity groups listed under problem areas 305 and 306. These ratings were then used for discussion and a final recommendation by the Task Force. No attempt was made to make specific recommendations for the future allocation of SMY's for problem areas 308, 309, and 313. Rather, the Task Force suggested commodities and areas which should be given major emphasis for short-term and long-term research. We assumed as a maximum limit the total SMY's projected for 1977 by the Joint USDA-SAES Task Force which conducted the Long Range Study.

Within this framework, an evaluation and review of each of the assigned problem areas is presented in three parts:

1. Objectives
2. Recommended Research Effort--SMY's for 1972 and 1977 with justifications where appropriate.
3. Situation--background of economic importance, degree of mechanization of specific commodities and major problem areas.

B. Research Problem Area 305--Mechanization of Fruit and Vegetable Crop Production

1. Objectives:

To reduce farm labor requirements and improve efficiency in the production of fruits and vegetables through mechanization. More specifically the objectives are:

a. Develop principles relative to mechanical and rheological properties of fruits and vegetables as they affect handling operations.

b. Develop machines and improved machine components to plant, cultivate, and harvest specific crops, particularly where this is now a hand operation.

c. Develop precision devices, particularly for planting operations.

d. Develop tillage units to minimize power requirements, number of operations, and to provide the optimum seed bed conditions.

e. Develop varieties adapted to mechanization of production.

2. Recommended research effort:

Recommended scientist man-years for 1972 and 1977 by commodity groups in problem area 305 are as follows:

Commodity	Scientist Man-years		
	Inventory FY 1966	Recommended for 1972	Recommended for 1977
B9 Citrus and ST fruits.....	14.2	40	58
B10 Dec. & Sm. Fr. & Nuts.....	22.5	43	61
B11 Potatoes.....	4.2	4	4
B12 Vegetables.....	21.0	30	43
B97 Plant Science.....	2.5	3	3
B99 Not Allotted.....	0.5	0	0
Totals.....	64.9	120	169

The recommendations for increases in SMY's relate directly to the need for increased engineering effort, and do not include the other disciplinary inputs. Teams of agricultural engineers, horticulturalists, plant breeders, food scientists, agricultural economists and others are essential in mechanization research. However, it is assumed that the non-engineering scientists to man these teams will be provided from other appropriate research problem areas.

Three commodity categories were considered high in priority for increased allocation of SMY's during the next decade. Of special urgency in the near future is the need for a rapid increase in the engineering effort on the mechanization of the citrus harvest. Thus, the Task Force recommends nearly a threefold increase in SMY's by 1972 with a further moderate increase by 1977.

A number of deciduous tree fruit crops also have critical needs for production and harvest mechanization. While the individual needs are not as immediate as in citrus production, the diversity of the crops necessitates a substantial, almost threefold, increase in the engineering effort by 1977.

Although remarkable progress has been made in the mechanization of production and harvest of a few vegetables such as tomatoes for processing, sweet corn, carrots, peas, and snap and lima beans, progress has been slow for others because of lack of uniform maturity and the inability of the vegetable to survive the treatment it receives from mechanized equipment. Mechanization of one or more crops in an area often reduces the total opportunity for employment available in an area. This puts a special urgency on those crops not now mechanized. Thus, these factors plus the diversity of vegetable crops justify an increase of double the current allocation of SMY's by 1977.

3. Situation:

Fruits and vegetables are frequently described as specialty crops. They can be further characterized as requiring intensive use of management, labor, and the capital inputs of machinery, fertilizer, and pesticides. Because of the number of crops and the diversity of production practices, the discussion of fruits and vegetables is presented by the major commodity groups of citrus and subtropical fruits, deciduous and small fruits and tree nuts, potatoes, and vegetables.

a. B9 - Citrus and Subtropical Fruits

Citrus sales for the 1966-67 season were a record 11.4 million tons, 31 percent above the 8.7 million tons sold in the 1965-66 season (table 5). With increased production, the value of the 1966-67 citrus crop was $439 million, 14 percent below the value of the 1965-66 production. Processors used 67 percent of the U. S. citrus produced in the 1966-67 season compared with 62 percent the previous season.

The bearing acreage of citrus was estimated at about 808,000 acres for 1965-66 crop season. 4/ Of significance for the future is the substantial acreage of nonbearing citrus. In contrast to a declining trend in prices received by growers, the cost of hand picking has increased by 60 to 70 percent in the last 10 years.

Cultural practices in citrus production are highly mechanized. Yet, the picking operation is done by hand. Some mechanical picking aids, platform and picker positioners have been developed. The fruit handling operation between grove and plant is partly mechanized.

The harvest operation is crucial. Factors such as increasing scarcity of labor, rising wage rates for seasonal workers, declining productivity of labor, and concern over the living and working conditions of migrant workers, coupled with increasing acreage and production of citrus are incentives for producers to find lower cost methods of harvesting.

All of the mechanical harvesting techniques developed so far cause more injury to the fruit than hand harvesting. Thus, grapefruit and oranges (excluding valencias) intended for processing will likely be first to be harvested mechanically.

Research to develop alternative methods of mechanical harvesting citrus has been conducted over the last 15 years. At least two types of mechanical harvesters, a shaker system and a blower system, have undergone field tests. Two of the shaker type machines were commercially produced for the 1966-67 season for further testing.

4/ Florida Agricultural Statistics--Citrus Summary, 1966. Florida Crops and Livestock Reporting Service and Florida Department of Agriculture.

Table 5.--Citrus fruits: Utilization of sales and value, United States crops of 1965-66 and 1966-67 1/

Crop and season	Utilization of sales		Value of --	
	Fresh sales	Total processed	Production	Sales
	1,000 tons	1,000 tons	1,000 dols.	1,000 dols.
Total citrus fruits 2/				
1965-66	3,273	5,434	510,479	506,937
1966-67	3,684	7,689	439,201	436,823
Oranges				
1965-66	1,819	4,149	346,785	344,231
1966-67	2,080	6,021	295,544	293,868
Grapefruit				
1965-66	909	974	90,986	90,417
1966-67	1,008	1,263	69,031	68,657
Lemons				
1965-66	348	251	51,746	51,691
1966-67	365	322	56,138	56,079
Limes				
1965-66	11	6	2,025	2,001
1966-67	11	6	2,734	2,702
Tangelos				
1965-66	43	10	4,236	4,183
1966-67	58	18	3,604	3,572
Tangerines				
1965-66	143	44	14,701	14,414
1966-67	162	59	12,150	11,945

1/ Abstracted from Table 1, Citrus Fruits by States, 1965-66 and 1966-67, Statistical Reporting Service, USDA, Fr Nt 3-1 (10-67), October 1967.

2/ Oranges, grapefruit, lemons, limes, tangelos, and tangerines.

Engineers estimate the price of these machines will be between $25,000 and $30,000 during the first few years of production.

Citrus trees grow so slowly that breeding varieties better adapted to mechanical harvesting is a long range project. A more likely approach is that of developing chemical and horticultural techniques to facilitate mechanical harvesting. For example, chemists are attempting to find chemicals that would reduce the amount of force required to separate fruit from the tree. This would permit faster, more thorough harvesting with less damage to the trees.

Another idea advanced is planting citrus trees in hedgerows. This would allow mechanical harvesters to operate at full speed for the entire length of the grove. In more traditional groves, a lot of time and effort is wasted in moving the harvesting equipment from tree to tree.

Certain citrus fruits have characteristics that seem to be unfavorable to mechanical harvesting. Valencia orange trees contain blooms, immature fruit, and mature fruit at the same time. Tangerines and murcotts have to be clipped rather than pulled or shaken from the tree. Other specialty citrus is sold for fresh use and cannot withstand the additional bruising of mechanical harvesting.

Subtropical fruits are hampered by low yields, diseases, urbanization, poor markets and climatic conditions such as freezes and hurricanes. Production problems are therefore of immediate priority with these crops.

Dates have a farm value of over $3 million and a pack-out value of over $9 million. They grow in California on palm trees 30 to 50 feet high and thus the replacement of harvest labor with machines is desirable. About 65 percent of the 1965 to 1966 crop was harvested mechanically using the bunch-cut method of harvesting and bunch shakers recently developed.

In all commercial date-producing areas in the world the female date blooms are pollinated by hand. From three to six trips up the palm during the season are necessary. There is no attractant in the female bloom which will cause insects to bring pollen to it. However, satisfactory pollination by air movement can usually be obtained if male palms are located in proper relation to female palms but the California plantings are not arranged in such a manner. The 1965 date crop averaged about 20 percent

unpollinated (cull) fruit. Due to a labor shortage, pollination was not done at the proper time during March and April, 1965.

Almost complete mechanical harvesting of dates in California has been accomplished with the development of the bunch shaker and ARS engineering research on date harvesting equipment was terminated in June 1965. Work continues on experimental aerial pollination with both fixed wing and rotary wing aircraft. Results are encouraging and this method may replace the costly and time consuming hand method.

Coffee production is valued at about $3 million. The labor requirements for the production of coffee was estimated in 1962 at 311,000 man-days. 5/

Labor for harvesting coffee in Kona, Hawaii, outside the farm families, is practically nonexistent. Since harvesting accounts for over 70 percent of the total farm labor input for coffee production, the grower's income is limited by the amount of coffee the farm families can harvest. Acreage has declined sharply and mechanical harvesting methods must be developed if the industry is to survive.

Research on picking aids continues. A commercially manufactured hand-held blueberry vibrator was modified to increase its effectiveness in removing ripe coffee cherries. The modified unit removes fruit rapidly, but no overall conclusion can be drawn without further field testing, including fruit collection and analysis of harvested coffee for ripeness. A privately financed experimental picking aid was field tested and evaluated. The back carried device included a pneumatic conveyor to carry fruit from the picker's hand to the container. Harvesting rate was slower than with the conventional waist-supported collecting basket. Research on complete mass harvest systems is underway. Equipment consisted of a shaker mounted on a temporary transport unit, a military jeep-mounted collecting frame, and a pneumatic conveying system. This equipment operated successfully, but more extensive field testing is required for full evaluation.

Engineering research on Kona coffee in Hawaii is progressing along two lines: (1) picking aids and (2) mass harvesting techniques using tree shakers.

5/ Coffee Cost of Production, University of Hawaii, 1962.

b. B10 - Deciduous and Small Fruits and Tree Nuts

In 1966, the value of production of deciduous and small fruits and tree nuts amounted to about $1.4 billion (table 6). The major crops, those valued over $100 million annual production, are apples, peaches, grapes, and strawberries. Pears and cherries accounted for $59 million and $43 million, respectively.

In the mechanization of deciduous and small fruits and tree nuts, we find far greater advances in mechanization of that portion of the crop which goes to processing, with little or no progress in the harvest of that part of the crop destined for the fresh market. Roughly about two-thirds of the $1.3 billion deciduous and small fruit crop goes to processing (table 6). Thus, it is important that labor-saving technology be developed for production in both the processed and fresh portions of the crop. Additional labor reductions are anticipated through improved pruning, thinning, harvesting, and handling techniques.

With the increasing cost and even shortages of seasonal labor, it is important that technology be developed for mechanically harvesting fruit for both the processing and fresh markets. Without the development of mechanical harvesting equipment for fresh fruits, the supply can be expected to be reduced with a consequent increase in price to the consumer.

A discussion of the problems of mechanization and labor requirements of all deciduous and small fruits and tree nuts as one group is not meaningful. Therefore, a brief situation statement is presented for each of the more important fruit and nut crops.

Apples. Research has developed platforms and man positioners to harvest fresh market apples. Special pruning techniques are required to complement these harvest aids. (Berlage and Yost 1967). For processing apples, tree shakers are a definite possibility. Shakers with 2-4 man crews replace about 15 workers and cost approximately 25,000 dollars. At present they cause extensive bruising and are difficult to move. Considerable quantities of leaves and twigs fall with the fruit. Hilly terrain is a problem. Adaptation of processing techniques is needed to more effectively utilize mechanically harvested fruit. (Farm Labor Developments 1967). Commercial shakers were used in 1966 in New York to harvest 25,000 bushels of 8

Table 6.--Production and value of specified deciduous and small fruits and tree nuts by market use, United States, 1966 1/

Crop	Quantity	Production: Percentage of crop harvested for: Fresh market	Production: Percentage of crop harvested for: Processed market	Value
	Million pounds	Percent	Percent	Million dollars
Non-citrus fruits:				
Apples	5,751	55	45	261.8
Peaches	3,407	35	65	155.7
Pears	1,499	38	62	59.3
Plums	190	48	52	15.7
Prunes	264			
Apricots	387	9	91	23.6
Cherries, sour	181	5	95	24.6
Cherries, sweet	232	37	63	43.1
Avocados	153	--	--	16.8
16 non-citrus fruits	20,664	33	67	940.6
Grapes	7,467	16	84	207.6
Berries:				
Strawberries	478	55	45	103.0
Bush berries	99	3	97	13.9
Nuts:				
Almonds	170			
Walnuts	192			
Filberts	24			
Pecans	323			
Macadamia	10			
Total nuts	719			149.4
Total value	--	--	--	1,414.5

1/ Abstracted from Fruits Noncitrus by States, 1965 and 1966, Part I, May 1967, Part II, July 1967 and Crop Production, 1967 Annual Summary, Statistical Reporting Service, U. S. Dept. of Agriculture.

different varieties. The quality of machine harvested fruit was comparable to typical hand-picked fruit of some firm fruited varieties. (Markwardt 1967).

Peaches. Cling peaches harvested with a shaker can be used for processing but do not make good halves. (Claypool et. al. 1963). Research on cling peaches indicated fruit can be protected from impact injury when falling 15 feet or more onto a collecting surface if deceleration devices and suitable padding are used. Selective harvest by maturity is not practical thus harvest is a once-over operation. Bark injury by shaker clamp attachment can and should be avoided. The shaker should remove a minimum of 95 percent of the marketable crop. Assuming a suitably constructed frame-conveyor and bin filler, the principal source of damage to harvested fruit is during removal and fall through the tree. An overall loss of about 10 percent could render machine harvest infeasible at this time. (Fridley et. al. 1966).

Pears. Man positioners are used for fresh pears. No commercial mechanical harvesting equipment is used at present.

Plums or prunes. Plums can be harvested with the same equipment that is used for cherries (shaker with catching frame). In test harvestings the plums were accepted for processing and met the normal grade standards. (Gaston et. al. 1960). Prunes can also be shaken, but a problem of uniform fruit maturity exists.

Apricots. No commercial mechanization has yet been adapted to apricot harvesting. Since the fruit does not mature evenly, harvest operations must entail at least two stages. Shaking the more mature fruit damages that which is still green.

Cherries, Sour. In 1966, 22 percent of the national crop was harvested mechanically. The equipment reduced harvesting and handling costs more than a million dollars and enabled the crop to be harvested with 6 to 7 thousand fewer workers than would have been required for hand harvesting. An estimated 40 percent of the total crop production and 47 percent of the Michigan Crop was harvested mechanically in 1967. For 1968, 60 percent of the total crop and 70 percent of the Michigan crop is expected to be harvested mechanically.

Mechanically harvested cherries contain more defects and stems than hand-picked fruit. In the processing plant, the cherries go through electronic sorters which remove defective fruit. It was estimated that about 75 percent of the cherries in 1967 were processed by electric sorters. The cherries also go over destemmers which have been recently developed. These units remove the stems from the fruit without bruising. One plant in northern Michigan used 125 people per shift before they obtained the electronic sorters and destemmers. They now handle the same capacity of fruit with 25 people.

Cherries, Sweet. Perhaps 10 percent of the total crop of sweet cherries will be harvested mechanically in 1968 compared with 2 percent in 1967. Problems are uniformity of ripening, excessive force required to remove immature fruit from the tree and incompatible methods of processing ripe fruit.

Avocados. The yield of avocados is usually low and often erratic. The thin-skinned fruit is delicate and must be handled carefully to avoid damage. Mechanization of this crop will be quite difficult.

Grapes. Fresh grapes are entirely harvested by hand. There is no commercial mechanical harvesting of processed grapes, but much research on mechanization is presently underway. The raisin type grape has been successfully mechanically harvested (Bilbo 1962). The grapes must first be trellis trained so that the fruit hangs below the plant. The harvester then clips the fruit from beneath the trellis and catches it on strips of paper. The paper and grapes are placed on the ground so that the grapes can dry. Another type of harvester has been developed for Concord grapes. Again, the grapes must be trellis trained, but the machine removes the grapes from the vines by shaking the wire which supports the plant. A conveyor transfers the grapes to a bulk tank. A machine has been designed to pick up filled grape boxes. This machine mounts on a farm tractor which pulls a wagon. The boxes run up a conveyor to a man who places them on a wagon.

Strawberries. Mechanical strawberry harvesting is still in the infant stage. At the present time, the machine designers are somewhat ahead of the plant breeders. Research is underway to determine the best combination of variety, strawberry bed preparation and machinery to do the job.

Blueberries. A blueberry harvester has been developed. At least two commercial manufacturers are building blueberry harvesters and 100 percent mechanical harvesting of cultivated blueberries is in sight.

Blackberries, raspberries, currants, boysenberries, loganberries, etc. No research has been initiated to mechanize bush berries for fresh market. Experimental machines for the processed crop are being developed.

Nuts. Nuts are harvested by shaking the tree and then picking the fruit up from the ground. (Western Fruit Growers, 1961) Pickup units using 3 different principles have been developed. The principles include vacuum, wedging, and raking and have been used on almonds, walnuts, tung nuts and pecans. Ground preparation is important, and a machine has been designed to prepare ground prior to harvest. Oregon filberts are partially mechanized. Macadamia nuts are harvested entirely by hand.

c. B11 - Potatoes

Potatoes are grown on about 1.4 million acres throughout the United States. Yields have been steadily increasing from a level of 60 cwt./A in 1910-14 to 195 cwt./A in 1960-64. A modest increase in national production in the U. S. occurs annually, averaging about 270 million pounds in recent years.

Improvements in mechanization have occurred over a long period of time and labor usage on a per acre or per ton basis has steadily declined. From a level of 76 man-hours per acre in 1910-14, labor dropped to 48 man-hours in 1960-64. Man-hours per ton of potatoes have dropped from 25 to 5.

Sixty percent of the crop was mechanically harvested in 1965, and the proportion is expected to increase. Since the stony and hilly soils in the East will continue to inhibit mechanical harvesting, there will probably be a continued shift of acreage to the West.

In 1965, about 46 man-hours were required to produce an acre of potatoes in the United States, of which 19 man-hours were used in preharvest and 27 in the harvest. In the preharvest period, 6 to 8 hours more labor were required on an irrigated crop than on a nonirrigated crop. Hand harvest required 40 man-hours per acre, while

machine harvest required only 13 man-hours per acre. Various conditions of climate, soils, yields, and economic conditions limit the use of mechanization of the crop in different growing areas.

Tillage, seeding, weed control, and harvesting have been adaptable to labor efficiencies through mechanization, but further improvements in design and innovation are feasible. Bulk handling in both pre-seeding and post-harvest is essential. Assessment of mechanized methods as well as other cost reducing or yield increasing methods of production must be continued if potato producers are to maintain a competitive position relative to the production of potato substitutes.

d. B12 - Vegetables

There are 27 principal vegetables produced for the fresh market and 10 principal vegetables grown for commercial processing. The 1967 volume of about 20 million tons of vegetables included approximately 11.1 million tons for the fresh market and 9.9 million tons for processing.

Approximately 1.7 million acres of vegetables are harvested for fresh consumption and roughly 1.9 million acres are harvested for processing. The total acres of vegetables harvested in 1967 was about 3.6 million acres.

The F.O.B. shipping value was $1.1 billion for vegetables sold for fresh consumption. The packing house door value of the vegetables sold for processing was $526 million. Total vegetable production had a value of $1.6 billion in 1967.

The list of principal vegetables is quite diverse in acreage, value and proportion produced for processing compared with the fresh market. However, tomatoes and lettuce are clearly the leaders in importance. In 1967, tomatoes accounted for more than $200 million for both processing and almost as much for the fresh market for a total value of about $416 million (table 7). Lettuce was also valued at over $200 million for the fresh market. Other vegetables of major importance include carrots, celery, sweet corn, onions, snap beans, green peas, and cucumbers.

The leading States in the production of vegetables sold for fresh consumption are California, Florida, Texas, Arizona, and New York. In processed vegetables, Wisconsin

Table 7.--Production and value of principal vegetables for processing and fresh market, United States, 1967 1/

Crop	Production		Value	
	Processing	Fresh market	Processing	Fresh market
	1,000 tons	1,000 tons	Mil. dol.	Mil. dol.
Asparagus	111.0	152.1	36.8	54.2
Beans, lima	115.7	14.4	20.5	3.4
Beans, snap	620.6	189.6	63.5	43.9
Beets	207.0	14.8	4.3	1.2
Cabbage	264.3	1,231.0	4.6	58.1
Corn, sweet	2,094.6	647.8	52.2	62.8
Cucumbers	589.6	238.6	54.0	32.0
Peas, green	581.8	4.0	63.4	1.1
Spinach	161.6	45.1	6.6	8.8
Tomatoes	5,164.2	1,024.2	220.2	195.7
Lettuce	---	2,134.0	---	212.4
Onions	---	1,419.8	---	90.9
Carrots	---	866.1	---	69.7
Total	9,910.4	7,981.5	526.1	834.2

1/ Vegetables--Processing, 1967 Annual Summary and Vegetables--Fresh Market, 1967 Annual Summary, U. S. Department of Agriculture, Statistical Reporting Service, December 19, 1967.

leads the nation in acreage harvested, followed by California, Minnesota, Washington and Illinois. However, in value of production, California is first, followed by Wisconsin, Washington, Oregon, and New Jersey.

Compared with the production of field crops and livestock, labor for the production and harvest of vegetables in the United States is most difficult to obtain. The seasonality of production precludes the average farmer from hiring year-round workers to do many of the tasks associated with the production and harvest. Areas of production extend from the East Coast to the West Coast, in southern United States, and northward to Canada. Seasonal progression of production and harvest overlap in many crops and areas. Many vegetables mature unevenly and require repetitive harvests.

The number of local workers in producing areas is nearly always less than that needed by the growers to adequately produce and harvest the crops. Growers historically have depended upon migratory labor that follows the crops.

Approximately 380 million man-hours were employed in 1967 to produce and harvest the nation's vegetable crops. The number of hours required has decreased at an annual rate of approximately 2.0 percent during the past decade. Much of the decrease that has been made in labor requirements is due to an increase in proportion of the vegetables marketed in processed form rather than in fresh form.

Mechanization has come to the vegetable industry in many ways. In cultural operations, mechanical seeders and planters are replacing or reducing the need for hand labor; mechanical thinners and selective herbicides are reducing hand labor needed for thinning and weeding in most vegetables.

Mechanical harvesting has made great progress in a few vegetables, while little or no progress has been made in others. During the past decade, equipment has been developed to successfully harvest sweet corn, tomatoes for processing, carrots, peas, snap beans, lima beans, cabbage and spinach.

Harvesting of vegetables for processing is more highly mechanized than harvesting of fresh market vegetables (table 8). The proportions harvested with machines vary widely, however.

Table 8.--Vegetables: Estimated proportions harvested by machine, 1965

Vegetables	Fresh market	Processing
	Percent	Percent
Asparagus	0	1/
Beans, snap	5	70
Beans, green lima	5	90
Beets	1/	95
Brussels sprouts	1/	1/
Cabbage	1/	20
Carrots	90	90
Corn, sweet	5	90
Cucumbers	0	1/
Onions	25	25
Peas, green	1/	100
Spinach	80	95
Tomatoes	0	15
Total	8	40

1/ Less than 5 percent.

Harvest of asparagus has been difficult to mechanize. Nonselective cutters are being used to a small extent in white asparagus. Selective, photo-electric eye machines are a few years away.

Harvesters have virtually replaced hand labor in picking snap and green lima bush beans. Acreages of pole beans, which are not particularly adaptable to mechanical harvest, are declining.

The arduous stoop-labor task of hand harvesting tomatoes for processing will soon be alleviated by mechanization. Determinate varieties have been developed that are adaptable to once-over machine harvesting. 6/ The mechanical method reduced costs about 40 percent below hand-picking costs. However, women are willing to work as sorters on the machines, but usually will not accept hand-picking jobs. In California, about 34,000 acres or 29 percent of the crop, was machine harvested in 1965, 112,000 acres or 68 percent in 1966, and 144,000 acres or 80 percent in 1967.

In some areas, celery is harvested with "muletrains." These are really packing-sheds on wheels with conveyor belts that extend over several rows onto which workers place the cut bunches. Other vegetables also are or have been harvested with these behemoths, including sweet corn for fresh market and lettuce. For the latter crop, a mechanical selective harvester is still in the research and development stage.

Progress in mechanizing harvest has been made for cucumbers, asparagus, cabbage, lettuce, onions, celery, Brussels sprouts and cantaloupes.

Mechanical harvesters of cucumbers for pickling are being used in some areas. Costs appear to about equal hand picking. While more research and developmental work on the machines is needed, early adoption on a broad scale is expected.

Mechanization of harvest of tomatoes for fresh market is not yet possible, but it is predicted that in 5 years the technology will be available.

6/ Determinate varieties are those on which nearly all the fruit ripens at one time.

The most difficult problem in mechanizing the harvest of vegetables is the lack of uniform ripening or maturing of the vegetable and the inability of the vegetable to survive the treatment it receives from mechanized equipment.

The solution to the mechanization of labor tasks associated with the production and harvest of vegetables requires that researchers consider all factors as variables. For example, before the tomato harvester could be used commercially, it was necessary for the geneticists and plant breeders to develop a new type of tomato plant--one that yields fruit that ripens simultaneously, resists mechanical injury and maintains the solid-acid ratio and flavor of present varieties. The variety developed has a different shape and size from the type consumers were accustomed to purchasing. Hence, food technologists joined the research team to develop a new method of processing the product. When the new variety was developed, a massive educational program was needed to teach the growers how to grow the new variety and how to prepare the fields for mechanization.

From a migrant worker's standpoint, one of his most important problems is earning a sufficient annual income to provide for his family and himself. Mechanization of one or more crops in an area often reduces the total opportunity for employment available in the area.

Since seasonal workers in vegetables are moving between jobs, they tend to go to those areas where the number of days of employment is the greatest. This puts a special premium on the mechanization of those vegetable crops not now mechanized. Asparagus, celery, lettuce, cantaloupes, broccoli, Brussels sprouts, cauliflower, onions, artichokes and a number of minor vegetables are in this category of urgency. A research program to mechanize these crops is needed immediately with the hope that the program can be reduced in 5 years.

C. Research Problem Area 306--Systems Analysis in Production of Fruit and Vegetables

1. Objectives:

Combine that set of production and marketing practices with land, labor, capital, and management inputs that will optimize income from production and marketing of fruit and vegetables. More specifically, this research should provide guidelines for farmers in determining:

a. The most profitable crops, crop sequences, and marketing systems.

b. Varieties, fertilizer and pesticide rates, and time and methods of application, plant population and moisture management, and other practices involved in production and marketing the crop or crops.

c. The amount of time available during which each operation can be performed most effectively under favorable, normal, and unfavorable seasons, and the probability distribution of their occurence.

d. The degree of timeliness of operation permitted by alternative type and size of equipment, as well as their relative cost.

e. The degree of mechanization of crop operations in response to the declining labor supply and rising labor cost.

2. Recommended Research Effort

Recommended scientist man-years for 1972 and 1977, for problem areas 306--Systems Analysis in Production of Fruit and Vegetables, are as follows:

Commodity	Scientist Man-Years Recommended		
	FY 1966	1972	1977
B9 Citrus and ST Fruits.....	1.6	3	3
B10 D & S fruits and tree nuts.....	1.4	3	6
B11 Potatoes.....	0.4	1	1
B12 Vegetables.....	2.6	4	6
B28 Miscellaneous & New Crops.....	0.9	4	4
B97 Plant Science.....	0.2	0	0
Total.....	7.1	15	20

The Task Force accepts the recommendation of the Long Range Research Planning Committee to increase SMY's from 7.1 in 1966 to 20 in 1977. In addition, the Task Force recommends that emphasis for the allocation of additional SMY's be given to B28, Miscellaneous & New Crops, B10, D & S Fruits and Tree Nuts and to B12, Vegetables.

To improve the capabilities and potential for systems analysis research the following tasks need to be accomplished:

a. Develop procedures for uniform collection, recording and retrieval of technical coefficients.

b. Improve mathematical models for simulating single crop production systems to permit delineation of factors requiring additional research and to develop procedures for preselecting some of the most profitable alternatives.

c. Continue systems analyses and test results to quantify potential gains from such analyses.

d. Develop model for simulating and analyzing alternatives at the multi-enterprise and industry level.

3. Situation

Most technological changes develop as a result of coordinated research effort by many scientific disciplines. Thus, the systems analysis approach must be interdisciplinary in character.

Systems analyses are needed to determine the most efficient combinations of practices for the several commodity or industry categories. Development of high-speed electronic computers and newer analytical models have opened the way to more comprehensive analysis of the relevant alternatives. Systems research may be profitable when dealing with the production process within a single enterprise. The development of mechanization will increase the number of alternatives within an enterprise. For example, potato producers have opportunities for choice of alternative methods of hand or mechanized operations from seed potato handling, to seeding, to weed control, to harvesting, to bulk handling techniques. All of these operations involve weighted judgments concerning the availability and cost of labor, the capital investment in equipment, the machine capacities, as influenced by limitations potentially or actually imposed by climatic and soil conditions.

Questions such as selection of optimum combinations of capital inputs, operations timing and use of labor for optimal efficiency within single enterprises are relevant for systems analysis. But the real forte of the systems approach comes at least one step of aggregation higher--at the multi-enterprise level. At this level, systems analysis can be used to determine optimums of production practices, capital investments, labor utilization, and land use to maximize profit for the firm in the short run as well as point the way for decision making in a longer range planning context. In a macro framework, the systems approach can be used effectively to analyze the economic relationships within an industry and between industries to answer broader questions of resource allocation, production mix, and public policy.

D. Research Problem Area 308--Mechanization of Production of Field Crops

1. Objectives:

To reduce farm labor requirements and improve efficiency in the production of field crops through mechanization. More specifically the objectives are:

a. Develop machines and improved machine components to plant, cultivate, harvest, and handle specific crops.

b. Develop precision devices and automated systems of machine operation.

c. Develop tillage units to minimize power requirements, number of operations, and provide optimum seedbed conditions.

d. Determine and develop mechanical and rheological properties of crop products to facilitate development of equipment and procedure for handling.

e. Modify varieties and cultural practices to provide plants adapted to mechanized operations.

2. Recommended Research Effort:

The recommended scientist man-years for problem area 308--Mechanization of Production of Field Crops are as follows:

Inventory	Recommended	
1966	1972	1977
100 SMY's	110 SMY's	120 SMY's

An examination of the SMY's allotted to RPA 308 indicates that they are spread among 15 commodity groupings and in many cases are so few as to almost be ineffective. It is also recognized that private industry supports a substantial research and development program related to farm mechanization and particularly mechanization of field crops. While the national program of research for agriculture recommends only a modest increase of 20 SMY's for RPA 308, this Task Force further recommends a change in the present distribution of SMY's so that larger efforts can be made in key areas.

Potential benefits of future mechanization of field crops stand out rather clearly when the total man-hours required and man-hours per $100 of production are examined by commodities. The three crops that appear to have the most potential for reducing labor requirements through mechanization are tobacco, hay, and cotton. Tobacco is the largest user of labor, 478 million man-hours, and requires 38 man-hours per $100 of production. Hay and cotton are also major users of labor with relatively high labor requirements, 12 to 26 man-hours, per $100 of production. The development of a technology that would reduce labor by only 1 percent in these crops would have significant benefits to agriculture. In sharp contrast, corn is also a major user of labor with 340 million man-hours in 1966, but only 7 man-hours per $100 of production. Improvement in mechanization of corn will likely increase production and improve quality of product rather than substantially reduce labor.

3. Situation:

A total of about 8.8 billion man-hours were used to produce field crops in the United States in 1940. Only 2.7 billion man-hours were used in 1967, which was almost a third less labor than a decade earlier and reflects the continued progress in mechanization of field crops.

Production per man-hour for all crops has increased about 59 percent since 1957-59 as result of increased mechanization and the adoption of both labor-saving and yield-increasing technology. Most of this gain can be credited to feed grains and cotton where increases in productivity have amounted to 118 percent and 88 percent, respectively during the past decade. In contrast, labor productivity increased only 27 percent for tobacco, 34 percent for hay and forage, 20 percent for fruits and nuts, and 39 percent for vegetables.

In the production of field crops, technology is now available which permits most, if not all, functions to be done by machine. Potential advances in the productivity of labor and in the mechanization of field crops are likely to occur in the substitution of larger machines for smaller ones and the redesign of current machines or systems to increase relative efficiency. For example, increased traffic by tractors in tillage and harvesting operations compact the soil and reduce yields and increase soil erosion. Such problems suggest the need for minimum or reduced tillage systems of production. Many of the tillage tools cannot be adjusted to produce the desired soil conditions, and planters still are not capable of precision placement of seeds to the degree usually desired.

In some instances, machines may reduce quality and quantity of production. Thus, while most operations in the production of field crops have been mechanized, further refinement is desirable.

In the harvesting of corn for grain, we find an interesting paradox where farmers are rapidly shifting from picking ear corn to field shelling. Most of the varieties of corn were not developed for shelling and the machine was basically designed to harvest wheat. The use of this machine, particularly at high moisture contents which are desirable to minimize field losses, results in injury to the kernels so that deterioration occurs at a more rapid rate. Soybeans, likewise, are harvested with the machine designed for small grain harvest and consequently field losses are frequently high because of shattering and inability to provide precision control of the cutter bar and platform.

The development of the pick-up baler was an important innovation in significantly reducing labor in the harvesting of hay. But standard bales, round or rectangular, are still difficult to handle during storage and to distribute to livestock. Hay pelleting or possibly wafering show some promise, but they have not solved the problems of curing and harvesting high quality hay. Wafering machines are operational, but are generally restricted to custom or large operations and to geographic areas of low humidity.

The effects of advances in mechanization have varied among the field crops. Labor used for hay and silage crops decreased rather slowly until the 1945-49 period when it dropped sharply, reflecting the rapid adoption of the pick-up baler and the field forage harvester. The decline in labor used per acre of corn and small grains, which began in the 1910-14 period was accelerated during World War II when man-power on farms declined and number of tractors, grain combines, and corn pickers increased substantially. Rice, peanuts, and cotton are now almost completely harvested by machine.

Only one crop, tobacco, has run counter to the downtrend in labor used per acre. Requirements per acre increased from 464 man-hours per acre in 1950-54 to 488 in 1960-63. Data for prior periods show that this is the continuation of a long-time trend, as labor used per acre of tobacco increased by 132 man-hours between 1910-14 and 1960-63, or from 356 to 488 hours. Even so, the time required to produce 100 pounds of tobacco decreased from 44 to 27 man-hours, as tobacco yields more than doubled and some labor-saving gains

were made in preharvest operations.

Mechanical transplanters are now used for setting the major portions of tobacco plants in the field. Transplanting mechanically requires an average of about 8 man-hours per acre less than transplanting by hand. Chemicals which inhibit sucker development in tobacco have gained widespread use in the flue-cured areas. The use of chemicals requires about 14 man-hours per acre less than suckering by hand. Mechanization of the harvest operation still lags although several experimental mechanical harvesters have received some attention.

E. Research Problem Area 309--Systems Analysis in Production of Field Crops

1. Objectives:

Combine that set of production and marketing practices with land, labor, capital, and management inputs that will optimize income from production and marketing of field crops. More specificially, this research should provide guidelines for farmers in determining:

a. The most profitable crops, crop sequences, and marketing systems.

b. Varieties, fertilizer, and pesticide rates, and time and methods of application, plant population and moisture management, and other practices involved in production and marketing the crop or crops.

c. The amount of time available during which each operation can be performed most effectively under favorable, normal, and unfavorable seasons, and the probability distribution of their occurrence.

d. The degree of timeliness of operation permitted by alternative type and size of equipment, as well as the relative cost.

e. The degree of mechanization of crop operations in response to the declining labor supply and rising labor cost.

2. Recommended Research Effort

The recommended scientist man-years, for problem area 309--Systems Analysis in Production of Field Crops, are as follows:

Inventory	Recommended	
1966	1972	1977
43 SMY's	57 SMY's	72 SMY's

The Task Force endorses the recommendation of the Long Range Study of Agricultural Research to increase the SMY's from 43 in 1966 to 72 in 1977. No attempt was made to allocate SMY's by commodities. Rather, the emphasis should be on interdisciplinary approach to the development of methodology, collection of data and analysis. The current allocation of

SMY's is weighted heavily by economists. To be effective, systems analysis requires the joint efforts of the agronomists, the engineers, and the economists.

To improve the capabilities and potential for systems analysis research, the following tasks need to be accomplished.

a. Develop procedures for uniform collection, recording and retrieval of technical coefficients.

b. Improve mathematical models for simulating single crop production systems to permit delineation of factors requiring additional research and to develop procedures for preselecting some of the most profitable alternatives.

c. Continue systems analyses and test results to quantify potential gains from such analyses.

d. Develop models for simulating and analyzing alternatives at the multi-enterprise and industry level.

3. Situation

Most technological changes develop as a result of coordinated research effort by many scientific disciplines. Thus, the systems analysis approach must be interdisciplinary in character.

Systems analyses are needed to determine the most efficient combinations of practices for the several commodity or industry categories. Development of high-speed electronic computers and newer analytical models has opened the way to more comprehensive analysis of the relevant alternatives. Systems research may be profitable when dealing with the production process within a single enterprise. The advent of mechanical harvesting and conditioning will increase the number of alternatives within an enterprise. For example, grain producers have opportunities for choice of alternative methods of mechanized harvesting, conditioning and storage of their crops. All of these operations involve weighted judgments concerning the availability and cost of labor, the capital investment in equipment, the machine capacities, as influenced by limitations potentially or actually imposed by climatic, soil, and other conditions.

Questions such as selection of optimum combinations of capital inputs, operations timing and use of labor for optimal efficiency within single enterprises are relevant for systems analysis. But the real forte of the systems approach comes at least one step of aggregation higher--at the multi-enterprise level. At this level, systems analysis can be used to determine optimums of production practices, capital investments, labor utilization, and land use to maximize profit for the firm in the short run as well as point the way for decision-making in a longer range planning context. In a macro framework, the systems approach can be used effectively to analyze the economic relationships within an industry and between industries to answer broader questions of resource allocation, production mix, and public policy.

F. Research Problem Area 313--Improved Livestock and Poultry Management Systems

1. Objectives

To increase efficiency in the use of labor and of capital in the form of buildings, equipment, feed and animals in the production and marketing of animal products. More specifically the objectives are:

a. Develop improved methods of farm handling, processing, and storing feeds.

b. Reduce drudgery and manual effort in livestock production.

c. Reduce labor, equipment, facility, and land requirements in a systems context.

d. Develop more efficient methods of waste collection and removal from barns and feed lots.

e. Improve methods of waste disposal, including possible salvage use.

f. Develop greater labor efficiency through systems engineering.

g. Identify efficient breeds and breeding systems to meet animal improvement objectives.

h. Develop optimum systems of management of breeding herds and flocks.

i. Determine the relationship between production efficiency and types and location of feed supply, markets, size of production units, and production technology.

j. Increase per-acre returns through better livestock management with respect to stocking rates, grazing systems, and other practices.

k. Combine biological, economic, and physical data into improved tools for decision making.

l. Improve personal and fire safety in livestock production.

2. Recommended Research Effort

The recommended scientist man-years, for problem area 313--Improved Livestock and Poultry Management Systems, are as follows:

Inventory	Recommended	
1966	1972	1977
134 SMY's	184 SMY's	233 SMY's

Recognizing the diversity of the research classified under this problem area, the Task Force did not attempt an in-depth review and evaluation. The Task Force was concerned primarily with the objectives directly related to labor and mechanization and concurs in the recommendation to increase the SMY's from 134 in 1966 to 233 SMY's in 1977. However, within the focus of farm labor and mechanization research, materials handling problems including waste disposal should be given prompt attention. Recognizing that substantial efforts are being made to obtain funds for a large-scale attack on waste disposal, the Task Force urges that the program be implemented since improved technologies in manure handling and disposal will likely reduce labor requirements in livestock production. In addition, emphasis in the allocation of new SMY's and even reallocation of current SMY's should be given research related to labor-saving equipment for general cleaning, manure removal, and sanitation.

An accelerated research program to reduce labor and lower costs of livestock production should have the following characteristics:

a. A multi-discipline approach involving Agricultural Engineering, Animal Husbandry and Economic Research.

b. Analyses involving evaluation of labor-saving technology relative to the cost of change, effect on animals, and product quality.

c. Diverse locations of research to cover a variety of conditions for each class of livestock.

3. Situation:

Implied in the description of the problem area concerned with improved livestock and management systems is increased efficiency and optimization of all inputs. In production of animal products, management involves the efficient use of labor and capital in the form of buildings, equipment, feed, and the animals.

Of concern to the livestock industry are the different economies associated with the production of various types of livestock. For example, broiler production is a well integrated, highly developed production-management system with a minimum labor input. Broilers require only 4 man-hours to produce $100 of production. This is in contrast to other enterprises that have experienced limited degrees of improvement in production management as evidenced by the following man-hours to produce $100 of production: beef cattle--10; hogs--7; sheep and wool--17; milk--21; hens and eggs--16; and chickens raised--42 (table 2).

Production of broilers and turkeys, once minor enterprises, have attained commercial status on many farms. Mechanical and automated methods of feeding and caring for poultry are now common practices. By 1980, production of poultry products per man-hour is projected to more than double the 1967 level (table 3).

Milk cows traditionally have required more labor than any other kind of livestock. But in recent years, widespread use of labor-saving equipment, larger herds, and handling milk in bulk and with pipeline installations have drastically reduced labor requirements. In addition, improved breeding and more productive feeds and feeding methods have resulted in more milk per animal. Consequently, labor requirements per 100 pounds of milk produced declined 36 percent from 1950 to 1959. In terms of milk production per man-hour, time spent on milk cows was 79 percent more productive in 1967 than in 1957-59 (table 3). If this trend continues, about 54 percent fewer hours of labor will be required for milk production, even with the increased production required in 1980 (table 4).

Improvement in production of meat animals per man-hour of labor has lagged behind that in other livestock production. Many producers of cattle, hogs, and sheep use tractor-mounted forks and scoops for feeding and for cleaning sheds and lots; but much hand work is still done. Modern feeding systems, such as self-fed and automatically-timed feed grinders and mixers and pneumatic feed distributors, usually involve considerable investment in new or remodeled buildings, power units, and equipment. With labor available, it has not been economical to invest in labor-saving systems. However, production of meat animals per man-hour is projected to increase 91 percent above the 1967 level by 1980 (table 3). Such an improvement will mean a 38 percent reduction in man-hours required for meat production in 1980 (table 4).

Materials handling is basic to the reduction of labor in the mechanization of livestock production. Materials handling problems are concerned with feed, animal wastes, and animal products.

Much farmstead equipment has been adapted from industrial uses and does not have the reliability or the desired efficiency when operating in a farmstead environment. Since the farm market is small compared to large industrial markets and short-line manufacturing companies usually do not have the capital to invest in research, needed research to improve farmstead equipment often is not done. Thus, some USDA-SAES resources need to be allocated to the development and improvement of farmstead equipment and materials handling systems.

Labor requirements vary among classes of livestock, geographical and climatic areas, and livestock practices. The solution of the problems for swine producers will differ from those of the dairymen. The large beef feedlots of the West and Southwest differ from those in the Midwest. Climatic conditions are a major variable in forage handling, storage, and livestock production. Thus, research will be diverse in its activities and locations. New design of machines and changes in facilities and practices will likewise need to be unique for each of the wide variety of situations.

APPENDIX A

Guidelines for Scoring Criteria for Evaluated Research

As an aid in scoring each research criterion, the following guidelines developed by the Soybean Task Force were used:

Goals:

1. Very limited degree
2. Below average
3. Average
4. Above average
5. Very high degree

Scope:(Commodity value was considered the most useful factor in scoring scope.)

1. A local area, or a few counties--Commodity value less than $40 million--Affects less than .5 million acres or people.
2. A State or equivalent number of counties--Commodity value of $50 to $500 million--Affects .5 to 1 million acres or people.
3. A region or several States--Commodity value of $500 million to $1.5 billion--Affects 1 to 10 million acres or people.
4. Two or more regions or more than 1/3 of States--Commodity value of $1.5 to $15 billion--Affects 10 to 100 million acres or people.
5. National or international in scope--Commodity value of over $15 billion--Affects over 100 million acres or people.

Benefits:

Benefit/cost ratio per acre, person or other unit affected is--

1. About unity or less
2. About 3 : 1
3. About 9 : 1
4. About 27: 1
5. About 81: 1 or better

Other Criteria:

1. Very low
2. Below average
3. Average
4. Above average
5. Very high

APPENDIX B

Tables of Expenditures and SMY's Allocated to Labor and Mechanization Research Problem Areas for Fiscal Years 1966 and 1967

Appendix Table 1.--Research Program of State Agricultural Experiment Stations and United States Department of Agriculture Related to (305) Mechanization of Fruit and Vegetable Production by Commodity and Resource, Fiscal Years 1966 and 1967 1/

Commodity or Resource	Expenditures by Fiscal Years ($1,000)		Scientific Man-Years by Fiscal Years	
	1966	1967	1966	1967
B9 Citrus and Subtropical Fruit				
SAES	223	244	9.1	10.3
USDA	224	246	5.1	6.1
Total	447	490	14.2	16.4
B10 Deciduous and Small Fruits and Tree Nuts				
SAES	538	544	16.1	16.1
USDA	129	145	6.4	5.4
Total	667	689	22.5	21.5
B11 Potatoes				
SAES	46	58	2.2	2.4
USDA	44	36	2.0	1.0
Total	90	94	4.2	3.4
B12 Vegetables				
SAES	563	617	19.9	19.8
USDA	32	33	1.1	0.9
Total	595	650	21.0	20.7
B97 Plant Science				
SAES 2/	91	91	2.5	2.3
B99 Not Allotted				
SAES 2/	10	5	0.5	0.3
Total				
SAES	1,471	1,559	50.3	51.2
USDA	429	460	14.6	13.4
Total	1,900	2,019	64.9	64.6

1/ Data were abstracted from Volume I, Table I, "An Inventory of Agricultural Research," complied and coordinated by RPDES, U. S. Dept. Agr., June 1967.

2/ Only SAES funds and SMY's were allotted.

Appendix Table 2.--Research Program of State Agricultural Experiment Stations and United States Department of Agriculture Related to (306) Systems Analysis in Production of Fruit and Vegetables, by Commodity and Resource, Fiscal Years, 1966 and 1967 1/

Commodity or Resource	Expenditures by Fiscal Years ($1,000)		Scientific Man-Years by Fiscal Years	
	1966	1967	1966	1967
B9 Citrus and Subtropical Fruit				
SAES 2/	47	55	1.6	1.8
B10 Deciduous and Small Fruits and Tree Nuts				
SAES 2/	117	105	1.4	1.4
B11 Potatoes				
SAES 2/	16	13	.4	.3
B12 Vegetables				
SAES 2/	62	63	2.6	2.5
B28 Miscellaneous and New Crops				
SAES 2/	36	59	.9	2.1
B97 Plant Science				
SAES 2/	5	4	.2	.2
Total				
SAES	283	299	7.1	8.3
USDA	---	---	---	---

1/ Data were abstracted from Volume I, Table I, "An Inventory of Agricultural Research," compiled and coordinated by RPDES, U. S. Dept. Agr., June 1967.

2/ Only SAES funds and SMY's were allotted.

Appendix Table 3.--Research Program of State Agricultural Experiment Stations and United States Department of Agriculture Related to (308) Mechanization of Production of Field Crops by Commodity and Resource, Fiscal Years 1966 and 1967 1/

Commodity or Resource	Expenditures by Fiscal Years ($1,000)		Scientific Man-years by Fiscal Years	
	1966	1967	1966	1967
B14 Corn				
SAES	143	136	6.7	6.4
USDA	108	115	3.0	3.3
Total	251	251	9.7	9.7
B15 Grain Sorghum				
SAES	23	28	1.4	1.5
USDA	30	29	1.3	1.3
Total	53	57	2.7	2.8
B16 Rice				
SAES 2/	22	24	.7	.7
USDA	---	---	---	---
B17 Wheat				
SAES	46	50	2.2	2.5
USDA	14	15	.3	.3
Total	60	65	2.5	2.8
B18 Other Small Grains				
SAES	39	40	1.5	1.5
USDA	9	10	.2	.2
Total	48	50	1.7	1.7
B19 Pasture				
SAES	31	26	1.0	.8
USDA	76	80	2.1	2.1
Total	107	106	3.1	2.9
B20 Forage Crops				
SAES	352	286	11.1	9.3
USDA	218	195	5.3	5.1
Total	570	481	16.4	14.4
B21 Cotton				
SAES	622	583	18.7	18.0
USDA	1,049	1,261	19.4	23.0
Total	1,671	1,844	38.1	41.0
B22 Cottonseed				
SAES 2/	15	20	.5	.6
USDA	---	---	---	---
B23 Soybeans				
SAES	16	16	.8	.7
USDA	---	20	---	.2
Total	16	36	.8	.9

--Continued

Appendix Table 3.--Research Program of State Agricultural Experiment Stations and United States Department of Agriculture Related to (308) Mechanization of Production of Field Crops by Commodity and Resource, Fiscal Years 1966 and 1967 1/ - Continued

Commodity or Resource	Expenditures by Fiscal Years ($1,000)		Scientific Man-years by Fiscal Years	
	1966	1967	1966	1967
B24 Peanuts				
SAES	61	102	1.7	2.8
USDA	168	174	2.0	3.7
Total	229	276	3.7	6.5
B25 Other Oilseed Crops				
SAES	---	---	---	---
USDA 3/	37	36	1.2	1.0
B26 Tobacco				
SAES	314	205	6.0	6.8
USDA	101	113	2.0	2.0
Total	415	318	8.0	8.8
B27 Sugar Crops				
SAES	69	86	3.0	3.0
USDA	148	153	2.0	2.0
Total	217	239	5.0	5.0
B28 Miscellaneous and New Crops				
SAES	64	53	1.1	2.1
USDA	3	3	.1	.1
Total	67	56	1.2	2.2
B97 Plant Science				
SAES	79	93	2.7	2.6
USDA	51	31	1.1	.9
Total	130	124	3.8	3.5
B99 Not Allotted				
SAES 2/	21	12	1.2	.7
USDA	---	---	---	---
Total				
SAES	1,917	1,760	60.3	60.0
USDA	2,012	2,235	40.0	45.2
Total	3,929	3,995	100.3	105.2

1/ Data were abstracted from Volume I, Table I, "An Inventory of Agricultural Research," compiled and coordinated by RPDES, U.S. Dept. Agr., June 1967.

2/ Only SAES funds and SMY's were allotted.

3/ Only USDA funds and SMY's were allotted.

Appendix Table 4.--Research Program of State Agricultural Experiment Stations and United States Department of Agriculture Related to (309) Systems Analysis in Production of Field Crops by Commodity and Resource, Fiscal Years 1966 and 1967 1/

Commodity or Resource	Expenditures by Fiscal Years ($1,000)		Scientific Man-Years by Fiscal Years	
	1966	1967	1966	1967
B14 Corn				
SAES 2/	22	21	.6	.6
B15 Grain Sorghum				
SAES 2/	11	8	.4	.3
B16 Rice				
SAES 2/	6	22	.5	.5
B17 Wheat				
SAES 2/	12	13	.4	.4
B18 Other Small Grains				
SAES 2/	11	7	.3	.3
B19 Pasture				
SAES 2/	84	97	.7	1.0
B20 Forage Crops				
SAES 2/	49	56	1.7	1.5
B21 Cotton				
SAES 2/	76	126	2.2	2.9
B23 Soybeans				
SAES 2/	8	4	.2	.1
B24 Peanuts				
SAES 2/	1	2	.1	.1
B25 Other Oilseed Crops				
SAES 2/	1	1	---	---
B26 Tobacco				
SAES 2/	38	24	1.3	.8
B27 Sugar Crops				
SAES 2/	24	31	1.4	1.4
B28 Miscellaneous and New Crops				
SAES 2/	18	20	1.2	1.6
B42 The Farm as a Business Enterprise				
USDA 3/	1,125	1,159	30.8	34.5
B97 Plant Science				
SAES 2/	32	37	.8	.8
Total				
SAES	393	469	11.8	12.3
USDA	1,125	1,159	30.8	34.5
Total	1,518	1,628	42.6	46.8

1/ Data were abstracted from Volume I, Table 1, "An Inventory of Agricultural Research," compiled and coordinated by RPDES, U. S. Dept. Agr., June 1967.

2/ Only SAES funds and SMY's were allotted.

3/ Only USDA funds and SMY's were allotted.

Appendix Table 5.--Research Program of State Agricultural Experiment Stations and United States Department of Agriculture Related to (313) Improved Livestock and Poultry Production Management Systems by Commodity and Resource, Fiscal Years 1966 and 1967 1/

Commodity or Resource	Expenditures by Fiscal Years ($1,000)		Scientific Man-Years by Fiscal Years	
	1966	1967	1966	1967
B29 Poultry Total Funds				
SAES	950	963	24.4	24.0
USDA	367	372	7.0	7.4
Total	1,317	1,335	31.4	31.4
B30 Beef Cattle				
SAES	1,527	1,498	25.0	25.6
USDA	382	610	6.6	7.4
Total	1,909	2,108	31.6	33.0
B31 Dairy Cattle				
SAES	1,328	1,366	25.2	25.9
USDA	891	890	13.6	14.4
Total	2,219	2,256	38.8	40.3
B32 Swine				
SAES	562	594	13.2	14.6
USDA	198	200	2.9	2.9
Total	760	794	16.1	17.5
B33 Sheep and Wool				
SAES	383	340	7.1	7.3
USDA	389	498	2.6	3.5
Total	772	838	9.7	10.8
B34 Other Animals				
SAES	9	21	.1	.2
USDA	80	97	1.3	1.1
Total	89	118	1.4	1.3
B42 The Farm as a Business Enterprise				
USDA 2/	225	236	6.2	7.0
B98 Animal Science				
SAES	83	86	1.7	1.4
USDA	8	8	.1	.1
Total	91	94	1.8	1.5
Total				
SAES	4,842	4,868	96.7	99.0
USDA	2,540	2,911	40.3	43.8
Total	7,382	7,779	137.0	142.8

1/ Data were abstracted from Volume I, Table I, "An Inventory of Agricultural Research," compiled and coordinated by RPDES, U. S. Dept. Agr., June 1967.

2/ Only USDA funds and SMY's allotted.